

# UNPUBLISHED PRELIMINARY DATA

PRINCETON UNIVERSITY  
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## JP24 TRANSIENT PRESSURE MEASURING METHODS RESEARCH\*

### Status Report

for 1 January 1965 through 31 March 1965

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Transducer evaluation and improvement of laboratory equipment and techniques continued during this research period. A brief delay in evaluating instruments requiring high pressure coolant directed more of the research towards uncooled transducer assemblies, signal conditioning systems and instrumentation while the laboratory transducer coolant system was modified to receive a new high pressure vessel. A special heat transfer study was made using the flush diaphragm Dynisco PT134 transducers in rocket motor tests. Preliminary evaluation of several assemblies, on consignment from the Kistler Instrument Company, were started and the effect of passage length, connecting volume and geometry on the performance of transducers used with the Princeton Small Passage Technique was studied. Performance testing of the Sinusoidal Pressure Generator is under way after modification of the pressure chamber. Shock tube testing at various pressure-step levels was initiated and development of a computer program to yield phase and amplitude ratio vs. frequency was continued. Meetings were held with manufacturers, NASA technical personnel and other users of transient pressure measuring instruments to discuss current transducer performance and further improvement as well as future requirements for transient pressure transducers.

### Transducer Evaluations

#### 1. Dynisco Model PT134

Two instruments were returned to the manufacturer early in this period for further modification after electrical failure and coolant tube leaks had occurred during rocket motor tests. Modification included removal of material from the transducer body, replacing with a ceramic coating and remachining to original dimensions. One instrument was damaged during the coating process and could not be recovered. The second instrument, recently

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returned to Princeton, was also apparently damaged during the process and leaks coolant through the diaphragm. Negotiations with the manufacturer for replacement of these transducers is currently in process. Two other instruments, used for the heat transfer studies and one of which had a ceramic coated diaphragm, suffered the same type of electrical and coolant tube failures and have been returned for repair and further modification.

Although an original PT134 withstood an average coolant pressure of 2200 psig, these instruments have been evaluated at an average coolant pressure of 225 psig due to large excursions of coolant flow data with changes in coolant pressure level. Pressure drop vs. coolant flow at 1000 and 1200 psig average coolant pressure and static calibrations were performed during this research period. Despite the large shift in coolant flow data, compared to data previously collected at lower coolant pressures, and a transducer zero shift of -108 psi at the 1200 psig average coolant pressure level, linearity, hysteresis and transducer output sensitivity remained unchanged. Evaluation at elevated coolant pressures will resume when the PT134 transducers are returned.

Rocket motor configuration and transducer location were considered in the final analysis of heat transfer data collected from a PT134 bearing a ceramic coated diaphragm, an unprotected PT134 and a model PT49CF Dynisco transducer. An injector, designed specifically for combustion instability studies, produced a "hot" side in the rocket thrust chamber. Rocket motor tests, made early in this period and in which alternately placing the unprotected and ceramic coated PT134 transducers in the "cold" side of the motor had indicated substantial heat rejection by the ceramic, were repeated with the transducers located in the hot side of the thrust chamber. Resulting heat transfer data indicated no heat rejection by the ceramic nor did the data agree with that previously recorded from the model PT49CF transducer. Based on fairly well known PT49CF characteristics, data comparison indicates that more than 50 percent of the total heat transferred to the PT134 was through a transverse heat path when the instrument was placed in the more extreme environment. It is planned to repeat rocket motor test conditions and verify the above results by using a cooled adaptor to control environment for the PT134 transducers.

## 2. Kistler Model 616A

Evaluation of this unit has been completed in the Laboratory and the unit is on standby for rocket motor testing. The helium bleed version of this assembly (Model 616H) has been delivered to Princeton and is scheduled for early evaluation. Another model, in which a multi-hole or "sieve" diaphragm is used to protect the miniature quartz transducer used in the assembly, is expected shortly.

## 3. Electro-Optical Systems PT15C-2

Major efforts to complete the evaluation of the PT15C-2 at simulated cryogenic coolant conditions were unsuccessful early in this period. In an effort to investigate the effects of coolant on dynamic response, the transducer was subjected to repeated shock tube tests while admitting liquid nitrogen chilled helium to the transducer. Because of difficulties experienced in obtaining tailored interface conditions while admitting the cold gas, such testing has been abandoned for the present. Testing will resume during the next period with a restriction placed in the transducer coolant tube to reduce the influx of cold gas.

#### 4. Aerojet-General Corporation HB3X

Information received from the manufacturer suggested that dynamic performance was affected by the amount of retaining torque placed on the device. Repeated testing, at reasonable mounting torque values, produced the same dynamic response data. The unit was used extensively during this period to determine phase lag vs. frequency in the Sinusoidal Pressure Generator and also to check theoretical performance of a 3/4 inch length passage with a known connected volume and geometry. Rocket motor tests are scheduled for the device and delivery of the latest model (HB4X) is expected soon. A technical note on performance of the HB3X will be published early in the next period.

#### 5. Kistler Model 614X

Preliminary evaluation of this version of the Princeton Small Passage Technique was begun late in this period. Difficulty in establishing a satisfactory helium bleed flow is causing some delay in the evaluation. Rocket motor testing is scheduled for early May.

### Laboratory Equipment and Techniques

#### 1. Small Passage Technique

A modified uncooled version (JP24-L030) of the advanced cooled probe Princeton Small Passage Technique (JP24-L029) was manufactured with the necessary accessories for the study of passage length, connected volume and geometry effects on passage connected transducers. Excellent agreement with the theoretical has been obtained for several passage lengths and connecting or instrument volumes. The work will continue through the next period of research as an effort to improve upon the technique. One of two cooled probe units (JP24-L029), manufactured at the Marshall Space Flight Center, is expected at Princeton for evaluation in the near future.

#### 2. Sinusoidal Pressure Generator

The appearance of signal noise and pressure wave shape distortion, while testing a new wheel assembly and nozzles, indicated that pressure chamber volume must be decreased in the machine. The wheel and nozzles were designed to increase frequency range, operating pressures and to reduce test gas consumption. The pressure chamber was designed around the rather large Photocon 352A transducer. Photographed oscilloscope data, across the current range of frequencies available from the machine, were accumulated for comparison purposes prior to "sleeving" or reducing chamber volume as a step in the equipment improvement program. Depending on results produced by sleeving the chamber, a new chamber will be designed to elevate operating pressures and to accommodate Dynisco Model PT134 and smaller transducers.

#### 4. Shock Tube

Attempts to correlate transducer dynamic response, as determined

from shock tube data, with that of the Sinusoidal Pressure Generator and the development of a computer program to generate phase and amplitude ratio vs. frequency continued during this research period. Parallel data was taken, using two oscilloscopes at widely different sweep rates, to more accurately determine the shock pressure step. A test program was initiated whereby data will be taken at various shock pressure steps to remove or determine the cause of "beat" frequencies in the shock tube data. This program will also provide a variety of inputs for the computer program.

#### Other Work

A control panel and helium system for calibrating small orifices used in the helium bleed adaptors was installed and is functioning both to calibrate and to supply helium to Small Passage Technique adaptors in the Sinusoidal Pressure Generator.

A large effort went into providing the laboratory with a source of high pressure coolant. A steel solid wall cylinder, rated at 2000 psi working pressure, was cleaned, internally coated and installed in the laboratory. The existing plumbing was modified to receive the new vessel and a similar system is being considered for the rocket test cells.

Work to improve signal conditioning and instrumentation continued with several pieces of equipment ordered on 30 day consignment to Princeton. This equipment consists of phase meters and digital voltmeters for use with the Sinusoidal Pressure Generator and d-c power supplies and amplifiers for general use.

Meetings were held with Dynisco representatives, to discuss performance and further modification of the Model PT134 and with the Kistler Instrument representatives in which variations of the Model 616 and other models were discussed.

Design and performance of currently available transducers, as well as prototypes of advanced instruments and techniques, were studied during the above period as a step in the melioration of previously published target characteristics.